

# **SHIFT PRESSURE CONTROL FOR AUTOMATIC TRANSMISSION**

## **BACKGROUND OF THE INVENTION**

**[0001]** The present invention relates to shift pressure  
5 control system and process for controlling a shift fluid  
pressure in an automatic transmission.

**[0002]** A Published Japanese Patent Application  
Publication No. H06(1994)-331017 shows a shift pressure  
control system for an automatic transmission.

## **SUMMARY OF THE INVENTION**

**[0003]** It is an object of the present invention to provide  
shift pressure control system and/or process for controlling  
a shift pressure for an automatic transmission properly  
even when an engine load is changed during a shift  
15 operation.

**[0004]** According to one aspect of the present invention,  
a shift pressure control apparatus for controlling a shift  
pressure to perform a shift in an automatic transmission,  
comprises: a controller to determine a starting input-  
20 torque-dependent pressure from a transmission input  
torque at a start of a shift; to hold the shift pressure at the  
starting input-torque-dependent pressure during the shift;  
to monitor an operating parameter representing an engine  
load of an engine connected with the automatic  
25 transmission, to detect an engine load change; and to  
modify the shift pressure to a modified pressure  
determined by modifying the starting input-torque-  
dependent pressure with a difference between a second  
engine-load-dependent pressure determined from the

engine load after the engine load change and a first engine-load-dependent pressure determined from the engine load at the start of the shift when the engine load change is detected.

5    **[0005]**    According to another aspect of the invention, a shift pressure control process for controlling a shift pressure to perform a shift in an automatic transmission, comprises: determining a starting input-torque-dependent pressure from a transmission input torque at a start of a  
10   shift; holding the shift pressure at the starting input-torque-dependent pressure during the shift; monitoring an operating parameter representing an engine load of an engine connected with the automatic transmission, to detect an engine load change; and modifying the shift  
15   pressure to a modified pressure determined by modifying the starting input-torque-dependent pressure with a difference between a second engine-load-dependent pressure determined from the engine load after the engine load change and a first engine-load-dependent pressure  
20   determined from the engine load at the start of the shift when the engine load change is detected.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0006]**    FIG. 1 is a schematic view showing an automatic transmission equipped with a shift pressure control system  
25   according to one embodiment of the present invention.

**[0007]**    FIG. 2 is a flowchart showing a shift pressure control process performed by the control system of FIG. 1.

**[0008]**    FIG. 3 is a time chart illustrating operations of the shift pressure control system shown in FIGS. 1 and 2.

[0009] FIGS. 4A and 4B are graphs, respectively, showing a characteristic of the shift pressure with respect to a transmission input torque, and a characteristic of the shift pressure with respect to an engine throttle opening,  
5 used in the control process of FIG. 2.

[0010] FIG. 5 is a time chart illustrating operations of a shift pressure control system of an earlier technology when there is no accelerator operation during a shift.

[0011] FIG. 6 is a graph showing a characteristic of an  
10 engine torque with respect to an engine speed.

[0012] FIG. 7 is a graph showing a characteristic of a torque converter torque ratio with respect to a torque converter speed ratio.

[0013] FIG. 8 is a time chart illustrating operations of  
15 the shift pressure control system of the earlier technology when the accelerator is operated during a shift.

#### **DETAILED DESCRIPTION OF THE INVENTION**

[0014] FIG. 5 illustrates the shift operation of an automatic transmission. At a shift command instant  $t_1$  at  
20 which a shift command is produced, a shift pressure control system starts the engagement control of the friction engagement elements for shifting such as clutches and brakes. In the process of the engagement control of the friction engagement elements, the shift proceeds to enter  
25 an inertia phase at an instant  $t_2$ . During the inertia phase, an effective gear ratio  $i$  varies from a before-shift-gear ratio to an after-shift-gear ratio, where the effective gear ratio  $i$  is specified as a ratio between a turbine speed  $N_t$  of the torque converter (transmission input speed) and a  
30 transmission output speed  $N_o$  ( $i=N_t/N_o$ ). Additionally, an

engine speed  $N_e$  (torque converter input speed) and the turbine speed  $N_t$  (transmission input speed) vary with time, for example, in a manner of time series, as shown in FIG. 5. At an instant  $t_3$ , the shift operation ends.

5    **[0015]**    During the shift, the engine speed  $N_e$  (torque converter input speed) and the turbine speed  $N_t$  (torque converter output speed) vary with time and thereby a speed ratio  $e$  of the torque converter ( $e=N_t/N_e$ ) varies with time as shown in FIG. 5.

10            When, for example, the engine speed  $N_e$  and the speed ratio  $e$  of the torque converter varies during the shift from the value of point A to the value of point B shown in FIG. 5, respectively, the shift pressure is controlled in the following manner.

15    **[0016]**    The engine torque  $T_e$  tends to vary with respect to the engine speed  $N_e$  as shown in FIG. 6. When the engine speed  $N_e$  varies from the value of point A to the value of point B as shown in FIG. 5, the engine torque  $T_e$  varies from the value of point A to the value of point B as  
20    shown in FIG. 6.

              The torque ratio  $t$  (output torque/input torque) of the torque converter tends to vary with respect to the speed ratio  $e$  of the torque converter as shown in FIG. 7. When the speed ratio  $e$  varies from the value of point A to the  
25    value of point B as shown in FIG. 5, the torque ratio  $t$  varies from the value of point A to the value of point B as shown in FIG. 7.

**[0017]**    The transmission input torque  $T_i$  is equal to the product obtained by multiplying the engine torque  $T_e$  by  
30    the torque converter torque ratio  $t$ , and the transmission

input torque  $T_i$  during the shift varies with time as shown by a broken line  $\alpha 1$  in FIG. 5.

If the control system employs the value of the transmission input torque  $T_i$  ( $\alpha 1$ ) as an shift control input torque  $T_{is}$  (input torque used for the shift control) without modification and determines the shift pressure  $P_s$  for governing the engagement control of the friction engagement elements, depending on the input torque  $T_i$  as shown by a broken line  $\beta 1$  in FIG. 5, the shift pressure  $P_s$  becomes excessive to cause a shift shock, as is evident from the variation with time (output torque wave form) of the transmission output torque  $T_o$  during the shift as shown by a broken line  $\gamma 1$ .

**[0018]** In order to prevent such an excessive increase of the shift pressure  $P_s$ , the control system as disclosed in the before-mentioned Japanese patent document (H06(1994)-331017) holds the shift control input torque  $T_{is}$  at the value of transmission input torque  $T_i$  at the shift start instant  $t_2$  detected in accordance with the effective gear ratio  $I$ , as shown by a solid line  $\alpha 2$  in FIG. 5, and determines the shift pressure  $P_s$  as shown by a solid line  $\beta 2$  in FIG. 5, in dependence on the thus-held shift control input torque  $T_{is}$  ( $\alpha 2$ ).

Thus determined shift pressure  $P_s$  ( $\beta 2$ ) does not become excessive, and the control system can provide a smooth time variation (output torque waveform) of the transmission output torque  $T_o$  during the shift as shown by a solid line  $\gamma 2$  as compared to the output torque waveform

of the conventional example as shown by the broken line  $\gamma 1$ , and thereby restrain a shift shock.

**[0019]** When the throttle opening TVO is changed by depressing accelerator pedal at an instant  $t2'$  during the shift as shown in FIG. 8, the control system of the the before-mentioned Japanese patent document (H06(1994)-331017) releases the hold of the value of the shift control input torque  $Tis$  and sets the actual transmission input torque  $Ti$  as the shift control input torque  $Tis$ , which causes the following problems.

**[0020]** When the throttle opening TVO is increased stepwise at the instant  $t2'$  as shown in FIG. 8, the engine speed  $Ne$  and the turbine speed  $Nt$  vary with time as shown by broken lines, respectively, instead of solid lines (the same as the solid lines shown in FIG. 5). And the speed ratio  $e$  of the torque converter and the effective gear ratio  $i$  vary as shown in FIG. 8.

With the increase of the engine torque due to the increased throttle opening TVO and the increase of the torque ratio  $t$  due to change of the speed ratio  $e$  of the torque converter, the transmission input torque  $Ti$  is increased as shown by a one-dot chain line  $\alpha 3$ , from the broken line  $\alpha 1$  (corresponding to  $\alpha 1$  in FIG. 5) of the case where the throttle opening TVO is not increased.

**[0021]** In this case, the control system of the earlier technology releases the hold of the shift control input torque  $Tis$  at the TVO increase instant  $t2'$  shown in FIG. 8, and sets the actual transmission input torque  $Ti$  ( $\alpha 3$ ) as the shift control input torque  $Tis$  as shown by a solid line  $\alpha 4$ .

Moreover, the control system is adapted to set the shift pressure  $P_s$  depending on thus reset input torque  $T_{is}$  ( $\alpha_4$ ), as shown by a solid line  $\beta_4$  in FIG. 8.

Therefore, though the actual increment of the transmission input torque  $T_i$  due to the throttle opening TVO increase at the instant  $t_2'$  in FIG. 8 is equal to the difference between  $\alpha_3$  and  $\alpha_1$  ( $\alpha_3 - \alpha_1$ ) as shown by  $\Delta T_{i1}$  in FIG. 8, the shift control input torque  $T_{is}$  is increased, after the release of hold of the shift control input torque  $T_{is}$  at the TVO increase instant  $t_2'$ , by the amount equaling to the difference between  $\alpha_3$  and  $\alpha_2$  ( $\alpha_3 - \alpha_2$ ) (this  $\alpha_2$  corresponds to  $\alpha_2$  in FIG. 5) as shown by  $\Delta T_{i2}$  in FIG. 8.

**[0022]** Accordingly, the increase of the shift pressure  $P_s$  after the release of hold of the shift control input torque  $T_{is}$  becomes as large as the difference between  $\beta_4$  and  $\beta_2$  ( $\beta_4 - \beta_2$ ) (this  $\beta_2$  corresponds to  $\beta_2$  in FIG. 5), beyond the actual increase  $\Delta T_{i1}$  of the transmission input torque due to the throttle opening TVO increase at the instant  $t_2'$ . This excessive increase in shift pressure  $P_s$  causes a large torque step in the transmission output torque  $T_o$  as shown by a solid line  $\gamma_4$ , resulting in a great shift shock.

**[0023]** On the other hand, if the control sysem keeps the hold of the shift control input torque  $T_{is}$  after the TVO increase instant  $t_2'$  as shown by the broken line  $\alpha_2$  in FIG. 8 and determines the shift pressure  $P_s$  depending on the input torque  $T_{is}$  as shown by a broken line  $\beta_2$  in FIG. 8, the transmission output torque  $T_o$  varies with time due to a shortage of the shift pressure  $P_s$  as shown by a broken line  $\gamma_2$ , which causes feeling of slow shift.

**[0024]** FIG. 1 shows a power train of a vehicle including an automatic transmission 1 having a shift pressure control apparatus according to an embodiment of the present invention as well as a shift control system for the  
5 automatic transmission 1.

The power train includes an engine 2 on the side of an input shaft of the automatic transmission 1. The automatic transmission 1 is drivingly connected with the engine 2 through an torque converter 3.

10 The power output of the engine 2 is adjusted by a throttle valve 4. The rotation of the engine 2 is inputted through the torque converter 3 to the automatic transmission 1.

The automatic transmission 1 converts an input  
15 rotation from the engine 2 into an output rotation of a rotational speed and a torque corresponding to a selected gear speed, and transmits the output rotation through an output shaft 5 toward drive wheels (not shown) for driving the vehicle.

20 **[0025]** The automatic transmission 1 includes a control valve body 6 used for shift control. The control valve body 6 has shift solenoids 7 and 8 inserted therein as well as an oil pressure source 9 built therein, although they are shown out of the control valve body 6 in FIG. 1 for convenience'  
25 sake.

The oil pressure source 9 creates a shift pressure  $P_s$  (generally referred to as a line pressure) by using working fluid discharged from an engine-driven oil pump 10, and delivers the shift pressure to the shift solenoids 7 and 8 to  
30 serve the later mentioned shift control of the automatic



transmission 1 and also to the torque converter 3 for its actuation.

**[0026]** The oil pressure source 9 includes an orifice 11, a line pressure solenoid 12, a pressure modifier valve 13  
5 and a pressure regulator valve 14.

The line pressure solenoid 12 operates under duty control as mentioned later. The line pressure solenoid 12 creates a pilot pressure corresponding to the desired shift pressure  $P_s$  with a discharge pressure supplied through the  
10 orifice 11 from the oil pump 10, and then applies the pilot pressure to the pressure modifier valve 13.

The pressure modifier valve 13 amplifies the aforementioned pilot pressure to supply to the pressure regulator valve 14. The pressure regulator valve 14  
15 adjusts the discharge pressure from the oil pump 10 to the shift pressure  $P_s$  which is proportional to the pilot pressure from the pressure modifier valve 13, and supplies the shift pressure  $P_s$  to the torque converter 3 and the shift solenoids 7 and 8.

**[0027]** The automatic transmission 1 determines the  
20 drive path (or selected gear speed) in the gear mechanism by supplying the shift pressure  $P_s$  to corresponding friction engagement elements through on/off combination of shift solenoids 7 and 8. The on/off action of shift solenoids 7  
25 and 8 and duty control of the line pressure solenoid 12 are governed by a transmission controller 21.

To meet this, the controller 21 receives input information about the opening degree of the throttle valve 4 (throttle opening: TVO) from the throttle opening sensor  
30 22, engine intake air quantity  $Q$  from an intake air quantity

sensor 23, engine speed Ne from an engine speed sensor 24, transmission output speed No (vehicle speed: VSP) from a vehicle speed sensor 25, and turbine speed Nt which represents the output speed of the torque converter 3 from a turbine speed sensor 26. In this example, the throttle opening TVO is used as the operating parameter representing engine load.

**[0028]** The controller 21 executes a control program shown in FIG.2 based on these input information and performs the shift control and shift pressure control as shown in FIG.3.

In the control program shown in FIG. 2, the first step S1 reads the vehicle speed VSP and the throttle opening TVO.

15 The next step S2 determines a desired speed for the present operating condition from the vehicle speed VSP and the throttle opening TVO based on the predetermined shift pattern.

Step S3 compares the present speed with the above desired speed and determines the need of the shift depending on whether the two speeds are different or not. Steps S1~S3 form a shift request decision loop which determines whether a shift operation is required or not.

**[0029]** If the controller decides that the present speed is the same as the desired speed and the shift is not required, the routine is returned to step S1 for the next iteration of the above shift request decision loop. On the other hand, if the controller decides that the present speed is not the same as the desired speed and the shift is required, the

routine proceeds to step S4 and the following steps to perform shift control and shift pressure control.

Step S4 produces a shift command at an instant  $t_1$  (a shift command instant), and also starts up the timer TMs to  
5 measure an elapsed time from the shift command instant  $t_1$  as shown in FIG. 3.

The shift command determines the on/off combination of shift solenoids 7 and 8 required for selecting the above desired speed, and outputs the corresponding signals to  
10 shift solenoids 7 and 8. By this command, the automatic transmission 1 can be shifted from the present speed to the desired speed.

**[0030]** In order to control the shift pressure  $P_s$  (shown in FIG. 1) to be applied to the friction engagement  
15 elements for this shift, the next step S5 calculates a transmission input torque  $T_i$  and an effective gear ratio  $i$ , and also reads the throttle opening TVO.

The transmission input torque  $T_i$  is determined by multiplying an engine torque  $T_e$  by a torque ratio  $t$  of the  
20 torque converter 3, where the engine torque  $T_e$  is determined from the engine speed  $N_e$  and the engine intake air quantity  $Q$  (refer to FIG. 6), and the torque ratio  $t$  is determined from the speed ratio  $e$  of the torque converter 3 (refer to FIG. 7) which is the ratio of the  
25 turbine speed  $N_t$  to the engine speed  $N_e$  ( $e = N_t/N_e$ ).

The effective gear ratio  $i$  is determined by dividing the turbine speed  $N_t$  (representing the transmission input speed) by the transmission output speed  $N_o$ .

**[0031]** Step S6 determines an input-torque-dependent  
30 shift oil pressure  $P_{si}$  (shift pressure determined in

dependence on the transmission input torque) from the transmission input torque  $T_i$  according to a pressure-torque characteristic map shown in FIG. 4A, and outputs this pressure  $P_{si}$  as the shift pressure  $P_s$  to the line pressure solenoid 12 shown in FIG. 1. Thus, the shift pressure  $P_s$  to be applied to the friction engagement elements which govern the progress of the shift is adapted to correspond to the transmission input torque  $T_i$ .

The pressure-torque characteristic map of the input-torque-dependent shift pressure  $P_{si}$  shown in FIG. 4A is preliminarily determined, by experiments on the design stage of the automatic transmission, as desired value for countermeasure against a shift shock, with respect to the transmission input torque  $T_i$  as a parameter.

**[0032]** Step S7 checks whether the above-mentioned timer  $T_M$  is not less than a shift start detection time  $T_{M0}$  (time to detect the start of the shift) as shown in FIG.3, or whether the effective gear ratio  $i$  is not more than (not less than, when downshifting) a shift start detection gear ratio  $i_0$  (gear ratio to detect the start of the shift); and thereby decides whether a shift start instant  $t_2$  (at which the shift starts, that is, the inertia phase starts) shown in FIG. 3 is reached.

During the period until the shift start instant  $t_2$ , the controller repeats steps S5 and S6 to determines the shift pressure  $P_s$  independence on the transmission input torque  $T_i$ , and makes the shift progress smoothly.

**[0033]** When step S7 decides that the shift start (inertia phase start) instant  $t_2$  is reached, the routine proceeds to step S8. Step S8 stores the throttle opening  $TVO$  (engine

load) at instant  $t_2$  as a first throttle opening value (or throttle opening hold value)  $TV01$ , and stores the transmission input torque  $T_i$  at instant  $t_2$  as a first input torque (or input torque hold value)  $T_{i1}$  which is used as the  
5 shift control input torque  $T_{is}$ .

Step S9 determines the input-torque-dependent shift pressure  $P_{si}$  from the first input torque  $T_{i1}$  stored at the shift start instant  $t_2$  according to the pressure-torque characteristic map shown in FIG. 4A.

10 Step S10 determines a throttle-opening-dependent shift pressure  $P_{st}$  (shift pressure determined in dependence on the throttle opening) from the first throttle opening value  $TV01$  stored at the shift start instant  $t_2$  according to a pressure-throttle opening (load) characteristic map  
15 shown in FIG. 4B, and sets this shift pressure  $P_{st}$  as a first throttle-opening-dependent shift pressure  $P_{st1}$ .

**[0034]** The pressure-throttle opening characteristic map of the throttle-opening-depending shift pressure  $P_{st}$  shown in FIG. 4B is preliminarily determined, by experiments on  
20 the design stage of the automatic transmission, as a desired value for countermeasure against a shift shock, with respect to the throttle opening  $TVO$  as a parameter.

However, the relation of the transmission input torque  $T_i$  variation to the throttle opening  $TVO$  variation differs  
25 among regions of the throttle opening  $TVO$ . Therefore, there is no correlation between the pressure-throttle opening characteristic map of the throttle-opening-dependent shift pressure  $P_{st}$  shown in FIG. 4B and the pressure-torque characteristic map of the input-torque-  
30 dependent shift pressure  $P_{si}$  shown in FIG. 4A.

**[0035]** Step S11 checks whether a flag FLAG is 0 or 1. This flag FLAG is a condition code which is set to one on the occurrence of a considerable change in the throttle opening TVO during the shift, as described later.

5        If FLAG is 0, that is, there is no considerable change in the throttle opening TVO during the shift, the routine proceeds to step S12. Step S12 reads the present throttle opening TVO. The next step S13 checks whether the absolute difference ( $|TVO - TVO_1|$ ) between the present  
10       throttle opening TVO and the first throttle opening value TVO<sub>1</sub> obtained at the shift start instant t<sub>2</sub> is more than or equal to a set value  $\Delta TVO_0$  illustrated in FIG. 3, to determine whether a considerable change in the throttle opening during the shift occurs.

15       The set value  $\Delta TVO_0$  is defined as a minimum value of the throttle opening change which arouses an actual sense of unpleasant shift shock.

**[0036]** When a considerable change in the throttle opening TVO during the shift occurs at the instant t<sub>2</sub>' shown in FIG. 3, and hence the answer of step S13 is YES,  
20       step S14 stores the throttle opening TVO (engine load) at the instant t<sub>2</sub>' as a second throttle opening value TVO<sub>2</sub>. Step S15 sets the above-mentioned FLAG to 1 to memorize the occurrence of a considerable change in the throttle  
25       opening TVO during the shift.

         However, when there is no considerable change in the throttle opening TVO during the shift, and hence the answer of step S13 is NO, the routine proceeds to step S16. Step S16 sets the above first throttle opening value TVO<sub>1</sub>  
30       as the second throttle opening valve TVO<sub>2</sub>.

Step S17 determines the throttle-opening-dependent shift pressure Pst from the second throttle opening value TVO2 determined in step S14 or S16 according to the pressure-throttle opening characteristic map shown in FIG.

5 4B, and sets the determined shift pressure Pst as a second throttle-opening-dependent shift pressure Pst2 (determined by the throttle opening at the time of a throttle operating). Then, the routine proceeds to step S18.

**[0037]** Once step S15 is executed, the answer of step  
10 S11 becomes negative, and the routine proceed to step S18 without executing steps S12~S17.

**[0038]** Step S18 determines the shift pressure Ps by adding a difference (Pst2-Pst1) between the second throttle-opening-dependent shift pressure Pst2 (determined  
15 at step S17 as illustrated in FIG. 4B) and the first throttle-opening-dependent shift pressure Pst1 (determined at step S10 as illustrated in FIG. 4B), to a starting input-torque-dependent shift pressure Psi (determined at step S9), and outputs the determined shift pressure Ps ( $\text{Psi} + (\text{Pst2} - \text{Pst1})$ )  
20 to the line pressure solenoid 12 shown in FIG. 1.

As a result, when a considerable change in the throttle opening TVO occurs at the instant t2' shown in FIG. 3, the shift pressure Ps to be applied to the friction engagement elements for governing the progress of shift  
25 operation is varied from the starting input-torque-dependent pressure to the modified pressure shown by a solid line  $\beta 5$  in FIG. 3 which is set equal to a sum of the starting input-torque-dependent pressure Psi and the throttle-opening-dependent shift pressure difference (Pst2-Pst1) which corresponds to the input torque change due to  
30

the throttle opening change  $\Delta TVO$  as shown by the broken line  $\beta 2$  in FIG. 3 (corresponding to the same reference numeral shown in FIG. 8).

**[0039]** The shift pressure  $P_s$  is conventionally set to the high value as shown by a broken line  $\beta 4$  in FIG. 3 (corresponding to the same reference numeral shown in FIG. 8) in response to the input torque  $T_i$  shown by a broken line  $\alpha 3$  in FIG. 3 (corresponding to the same reference numeral shown in FIG. 8). Consequently, the output torque  $T_o$  is increased sharply in the waveform shown by a broken line  $\gamma 4$  (corresponding to the same reference numeral shown in FIG. 8), with the result of a great shift shock.

By contrast, the shift pressure control system according to this embodiment determines the correction amount ( $P_{st2}-P_{st1}$ ) of the shift pressure  $P_s$  accurately in conformity with the input torque change due to the throttle opening (engine load) change  $\Delta TVO$ , and thereby restrains a shift shock effectively as intended with the waveform of the output torque  $T_o$  as shown by a solid line  $\gamma 5$  in FIG. 3.

**[0040]** Step S19 checks whether the above timer  $TMs$  measuring the elapsed time from the shift command instant  $t_1$  is not less than a shift end detecting time  $TMe$  (time to detect the shift end) shown in FIG. 3, or whether the effective gear ratio  $i$  is not more than (not less than, when down shifting)  $q$  shift end detecting gear ratio  $ie$  (gear ratio to detect the shift end) shown in FIG. 3 to determine whether a shift end instant  $t_3$  shown in FIG. 3 (an end of the inertia phase) is reached.



During the period between the instant t2 and the shift end instant t3, the above shift pressure Ps is continuously controlled by repeating steps S11~S18 to achieve the above advantageous effect. When the shift end instant t3 is reached, step S20 releases the hold or retention of the first throttle opening value (TVO1), the at-shift-start transmission input torque (Ti1), and the second throttle opening value (TVO2). Step S21 resets the above-mentioned flag FLAG and the timer TMs to 0 to prepare the next shift operation.

**[0041]** Additionally, in this embodiment, the controller is adapted to modify the shift pressure Ps only when a change in the throttle opening TVO is equal to or more than the preset throttle opening change  $\Delta\text{TVO0}$ . Therefore, the control system can prevent useless repetition of modification of the shift pressure Ps responsive to such a small change in the throttle operation not to cause a sense of unpleasant shift shock.

**[0042]** In the above embodiment, the controller is adapted to control the source pressure (generally called line pressure) of the automatic transmission as the shift pressure Ps. However, as an alternative, in the case of a direct driven valve type automatic transmission capable of controlling the working pressures of friction engagements individually, it is also possible to control direct-acting valves individually to obtain the above-mentioned effects.

**[0043]** This application is based on a prior Japanese Patent Application No. 2003-035898 filed in Japan on February 14, 2003. The entire contents of these Japanese

Patent Application No. 2003-035898 are hereby incorporated by reference.

**[0044]** Although the invention has been described above by reference to certain embodiments of the invention, the  
5 invention is not limited to the embodiments described above. Modifications and variations of the embodiments described above will occur to those skilled in the art in light of the above teachings. The scope of the invention is defined with reference to the following claims.